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ENVIRONMENTAL IMPACT ASSESSMENT METHODOLOGIES:

An Annotated Bibliography

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ENVIRONMENTAL IMPACT ASSESSMENT METHODOLOGIES: AN ANNOTATED BIBLIOGRAPHY

by

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INTRODUCTION

Today after four years of experience under the National Environmental Protection Act of 1969 the assessment of environmental impact remains more of an art than a science. Further research and testing of assessment methodologies is needed before Federal agencies can be assured that their procedures have satisfactorily incorporated both the spirit and the letter of NEPA. This material is intended to provide the first step.

The annotated bibliography herein is a comprehensive review of environmental assessment methodologies. It is complete to the extent possible given the current interest and subsequent continual publication in this area. Benefit/cost approaches are considered but not emphasized due to the real possibility of engaging in a tangent and becoming mired in the complex and arcane underpinnings of economic analysis. The annotations have been designed to render an objective picture of the salient information or arguments in each reference. The bibliography itself is of two parts: the first dealing with the methodologies themselves, and the second dealing with references that contribute directly to these methodologies.

This research has unearthed a broad spectrum of systems which strive to assume the nature of an assessment methodology in different ways. Richard Hueting's methodology which deals with a "decreased availability of functions" of an environmental component contrasts with the familiar prototypic Leopold Matrix as evidence of the character of this spectrum with which the researcher is presented. Varied and controvertible degrees of modelling (viz. A. K. Biswas) to the utter lack of modelling (viz. Bureau of Land Management) and admixtures (such as the methodology of Alden), as well as the varied degrees of computerization employed (from the system of Kane to the Tulsa Matrix to those of even lesser usage) provide a sampling of the number of planes on which such a spectrum extends.

The following set of criteria along which the proposed assessment systems might be compared and evaluated was found to be helpful by the authors:

(1) What kind of technique(s) does it employ?

descriptive/verbal
cost/benefit
matrix
algorithm
computer aided (data collection, computation, and statistical analysis)
computer modeled
graphic overlay
remote sensing

(2) What are its characteristics?

specialized training required
sophisticated equipment required
funding required
adaptability to change over time
universality of application
comprehensiveness
level of objectivity
level of complexity

(3) How are alternatives evaluated?

A) kinds of impacts considered:
ecological
economic
socio/cultural
unquantifiable (eg. aesthetics)
negative only, or positive and negative
primary only, or primary and secondary
short term only, or short and long term

B) summarizing the alternatives
array
ordinal ranking
provision for "red flags"

PERSPECTIVES IN THE LITERATURE ON ENVIRONMENTAL IMPACT METHODOLOGY

NEPA has provided the impetus for the re-evaluation and reformulation of much of the planning and decisionmaking process throughout the governmental realm. It is suggested by Barry Flamm* that when concern with NEPA's process and procedures dies down, quality and substantive aspects of environmental assessment can be more attended. Environmental assessment methodologies are only now coming to the forefront of concern in planning and decisionmaking spheres. How to choose or tailor an available methodology for environmental assessment is becoming the ratio pro qua for the investment of a vast amount of funds and man-hours.

James Jordan writes that the role of environmental quality in the traditional public decisionmaking process must be examined as a necessary basis for analyzing how environmental impact assessment should be accomplished. Jordan argues that assessment must not be one discrete entity and the planning process another. Further, he argues it is not possible to discuss a framework for assessment prior to consideration of assessment in terms of the broader planning process. These statements exemplify the need for having an assessment methodology which meshes effectively with planning requirements and objectives. In a supplementary manner, R. N. L. Andrews perceives three historic rationales in the relationship between environmental assessment and planning. Environmental assessment was first structured as a separate process from that of planning, then it became a source of information for the planning process and only recently has it been recognized as an inseparable and integral component of planning. An assessment methodology should not only mesh with one's planning requirements and objectives but should also integrate the same.

A proper assessment methodology then is an integral component of planning, not just an efficient adjunct. The qualification of the nature of this component has provided a wellspring of debate. Sager warns that it is premature to construct a framework of critical factors and associated value scales in the absence of a widely accepted philosophy of environmental values. Requiam, in a similar vein, asserts that there is difficulty in ranking individual environmental problems, even among dedicated environmentalists. Hill et al. feel that attitudes toward economic development will significantly influence the ranking of environmental problems. Sager adds that impacts associated with these environmental problems be couched in terms of man's ability to adapt or alleviate the impacts. These tenets point towards the conclusion of methodologies not only having to relate the causal link between pollutant and impact, but also having to incorporate changing value considerations and having to be congruous with the backdrop of environmentally related attitudes. Further, research must be conducted to assay attitudes and impute at least a degree of catholicity to the value scales employed in the assessment component of the planning process.

Adding more light on the nature of an assessment methodology, Anderson sees all techniques as precipitating into two forms - those that avoid the problems of benefit/cost analysis, and those that endeavor to augment such an approach. Roskin has tossed a caveat in the recent trends towards quantification in assessment. He warns that quantifying can result in twisted interpretations and a dangerous de-emphasis of those parameters which do not readily lend themselves to quantification - the very pitfalls of benefit/cost analysis. There are writers such as W.R.D. Sewell who feel that the assessment process itself incorporates too few benefit/cost considerations. Sewell states that the opportunity costs of using a resource for one purpose rather than another is too often not considered by the assessment technique.

Sorensen calls into question the scope of an appropriate assessment technique in a slightly different perspective. He suggests that secondary effects must be dealt with, and dealt with in cause-condition-effect networks. The consideration of these secondary effects must subsume economic, environmental, social, cultural and aesthetic factors.

The literature then paints an assessment methodology as a system that incorporates value considerations in the analysis of environmental, economic, aesthetic, social and cultural impacts, both direct (primary) and indirect (secondary). This analysis must be one which is not so quantitative as to attenuate the importance of parameters not readily quantifiable. Further, a methodology must be one which not only continuously integrates and complements the planning process but also synthesizes and defines changing values and attitudinal constraints.

* authors cited are found in the accompanying bibliography

PART A: METHODOLOGIES AND SYSTEMS FOR ENVIRONMENTAL IMPACT ASSESSMENT

"An Approach to Assessing Envrionmental Impact." David W. Fischer and Gordon S. Davies, Journal of Environmental Management, University of Waterloo, Ontario, Canada, Vol. 1, No. 3, July 1973, pp. 207-227, 8 figures.

A method of environmental analysis is proposed that expands the concept of environmental matrices. Three steps are used to identify and evaluate environmental feasibility: (1) a matrix for environmental baseline evaluation in terms of importance, present condition, and management, (2) an environmental compatability matrix in terms of introduced activities, and (3) a decision matrix for evaluating alternatives available (no project, structural and non-structural alternatives, locational alternatives). This methodology relies heavily on the use of multi-disciplinary teams to provide value scales and to perform the environmental analysis.

"Development of Environmental Indices." Robert Pikul, Statistical and Mathematical Aspects of Pollution Problems, J. W. Pratt, ed., pp. 103-121, 1974.

An index approach to environmental assessment. The author presents an initial formulation of environmental indices in 14 "environmental classes". A method of ranking indices while taking cost and value considerations into account is discussed. The assessment of impact is facilitated by tracking and analyzing the behavior of these indices. Each mathematical index is analyzed according to factors of impact, utility, value, cost and importance.

Environmental Analysis. Working Draft, Bureau of Land Management, August 1973, 126 pp., 2 charts, 4 diagrams, 2 figures.

An approach to environmental assessment which, in keeping with sections 102 (2) A & B of NEPA, uses an "Environmental Analysis Worksheet" that is both flexible and "open". The suggested environmental elements to be considered are listed in an "Environmental Digest". Impacts are evaluated on a scale of low-medium-high, positive and negative, as they relate to previously predicted Bureau standards. Accompanying remarks are an integral part of the ongoing worksheet process.

Environmental Analysis System. Report #R-1447, prepared for the Northern States Power Company, Minnesota, by Commonwealth Associates, Inc., Jackson, Michigan, September 1972, 55 pp., 2 diagrams.

The use of a matrix system in evaluating environmental impact is further developed by adding the adaptability and flexibility of a computer. The approach starts with the hierarchal cataloging of all factors, then quantifies impacts by assigning numerical values for magnitude and importance, and combines multiple considerations through the use of algebraic equations and weighting operations. The weighting of the individual elements, i.e., air versus water, is handled as an external consideration. The computer can modify the weighting operations as often as necessary in response to new thinking. This system bases environmental factor comparisons on a relative rather than an absolute basis.

Environmental Evaluation System for Water Resources Planning. Final report to the Bureau of Reclamation, January 31, 1972, Contract #14-06-0-7182, Battelle, Columbus Laboratories, Columbus, Ohio, 188 pp., 78 figures, 22 tables. Also found in Water Resources Research, Vol. 9, No. 3, June 1973, pp. 523-535.

A proposal for environmental impact assessment. The methodology proposed orders environmental categories, components, parameters, and measurements into a hierarchical structure. The study maintains that parameter weighting, the result of the compilation of value curves, allows for consistent action in project analyses. The expected future environment without the project is compared to the expected future environment with the project and any differences is measured in Environmental Impact Units (EIU). Provisions for "red flag" environmental sensibilities are also included in the system.

Environmental Guidelines. Western Systems Coordinating Council, Environmental Committee, Robert N. Coe, Chairman, Southern California Edison Company, December 1971, 96 pp.

The Environmental Guidelines are more of an approach or procedure than a methodology for environmental impact analysis. They suggest general areas and types of impacts to be examined without suggesting specific means for their measurement or evaluation. Intended as a planning tool for siting power generation and transmission facilities, the Guidelines have been used in the preparation of impact statements.

Environmental Impact Analysis: Philosophy and Methods. Robert B. Ditton and Thomas L. Goodale, eds., Proceedings of the Conference on Environmental Impact Analysis, Green Bay, Wisconsin, January 4-5, 1972, Sea Grant Publications WIS-SG-72-111, 171 pp.

Development of environmental impact statements in compliance with Section 102 (2) (C) of NEPA is variously viewed as one more burden on agencies already overtaxed, as an intrusion on agency prerogatives, as a bottleneck to placate anti-development interests, or as a new bureaucratic paper shuffle.

This book is a congeries of articles on the environmental assessment process. Authors evaluate present methods, suggest criteria around which future techniques should evolve, and provide interpretation as to the purpose and scope of the entire assessment endeavor. Articles of special interest are:

J. Armstrong: "Systems Approach to Environmental Impact;" calls for time-space grid systems that consider density, duration, and the synergistic effects occuring with other proposed systems.

P. Sager: "Conceptualizing Environmental Impact;" warns that it is premature to construct a framework of critical factors and associated values scales in the absence of a widely accepted philosophy of environmental variables.

E. Roshin: "Some Thoughts on Impact Statements and Mathematics," warns that quantification can result in twisted interpretations and dangerous de-emphasis of those parameters that do not readily lend themselves to quantification.

J. Sorensen: "Some Procedures and Programs for Environmental Impact Analysis;" states that it is necessary to deal with secondary effects. One should list possible environmental effects and then define salient ones due to aspects of scarcity or uniqueness. Recommends "cause-condition-effect" networks.

Krauskopf and Bunde: "Evaluation of Environmental Impact Through a Computer Modeling Process;" regards the essence of impact as the loss of diversity, recommends a computerized four phased "Regional Environmental Management Allocation Process" (REMAP).

Environmental Impact Assessment: A Procedure. Lloyd V. Stover, STV, Inc., Pottstown, Pennsylvania, Science Technology Vision, Inc., Report, May 1972, Sanders and Thomas, Inc., 1972, 12 pp., 4 figures.

A systematic approach to environmental impact assessment that proceeds from an initial environmental inventory to analysis of the predicted effects of the proposed development, and finally to evaluating the alternatives. Three areas of concern are identified: the environment, human well-being, and the proposed development. Data is analyzed through a method of assigning numerical values in terms of an Environmental Impact Index (EII), Alternative Proportional Value (APV), Functional Impact Value (FIV), and Environmental Impact Assessment (total FIV's).

Environmental Impact Assessment: A Procedure for Coordinating and Organizing Environmental Planning. Dr. Howard R. Alden, Thorne Ecological Institute, Boulder, Colorado, unpublished report, 45 pp., 14 tables, 10 figures.

Many of the stumbling blocks one faces in trying to integrate diverse ecological elements into a single "end product" are lessened by a recommended procedure of seven steps, from initial coordination and communication to final recommendations. This comprehensive procedure employs an environmental resource inventory, "Composite Strength of Relationship" and "Impact Relationship" matrices, map graphics, nonmonetary cost/benefit studies, and ranking operations in evaluating both linear and more complex environmental interrelationships.

Environmental Impact Assessment: Guidelines and Commentary. Thomas G. Dickert and Katherine R. Domeny, eds., University Extension, University of California, Berkeley, 1974, 238 pp., 4 tables, 11 figures, 4 pictures.

The day of the single purpose planning agency is past and agency procedures based on custom or tradition are no longer justified. Interaction and cooperation are needed between all parties concerned with the environment. This collection of papers reviews the State of the Art in environmental impact assessment. Areas covered include the suggested content and organization of environmental impact statements, legal aspects, review of assessment methodologies (including the Berkeley Environmental Simulation Project), case studies, and a summary of Federal and state guidelines and legislation.

Environmental Impact Assessment Study for Army Military Programs. Technical Report D-13, December 1973, Army Corps of Engineers, by Construction Engineering Research Laboratory, Champaign, Illinois, 170 pp. 25 figures, 13 tables.

Potential environmental impacts are identified by a computer-aided assessment program developed for Army activities. Eleven technical areas of specialty are used in describing the environment. Environmental impact analysis proceeds at 3 levels: (1) detailed level, (2) review level, and (3) controversial attributes level. "Ramification remarks" were developed for noting potentially important construction impacts, as well as procedures for minimizing adverse impacts.

Environmental Resources Management. Central New York Regional Planning and Development Board, prepared for Department of HUD, October 1972, available through the National Technical Information Service PB217-517, 42 pp.

This report examines environmental impact in its relation to resources management and regional planning. "Natural Resource Conditions" (such as steep slopes, shallow soils) are delineated. These are then used as a base for the "Environmental Impact Chart" which is actually a combination of two matrices: one which considers the resource conditions and methods of development, and the other which considers primary and secondary impacts. Matrix elements are coded for major direct, major indirect, minor direct, and minor indirect impacts. The authors tout the chart as having an abiltity to be employed in a variety of ways dependent on the needs of the user. A capability rating system predicated on the Chart for use in ecological values and regional development is proposed for land use planning.

Handbook: Applications of Remote Sensing and Computer Techniques for Recreation Planning. Vol. 1, 2, 3, & 4, for Bureau of Outdoor Recreation, March 1974, by University of Wisconsin, Madison, Wisconsin, illustrated, tables, charts.

This environmental assessment system is unique in its remote sensing data gathering and its computer generated overlays. Statistical methods for sampling the project area (divided into cells for study by random sampling) are documented. A total Impact Index (II) is calculated for each of the cells and compared to the Expected Impact (EI) on each. An "Immitation Data Bank" is proposed as an aid in the testing of other methodologies.

Handbook for Assessing the Social and Economic Impacts of Water Quality Management Plans. EPA, July 1973; and papers by Robert Rea of the Resource Planning Associates, Inc., of Cambridge, New York and Paris.

These studies propose a system for environmental assessment which is definable in two discrete components--Impact Identification and Impact Evaluation. The methodology relies heavily on input from Regional Planning Agencies and community groups. In the impact identification process objectives, by-products, short-term requirements and long-term requirements are considered. The authors state that due to the large number of impact cells to be scrutinized, priorities for in-depth analysis should be resolved by the contractor with major input from Resource Planning Agencies. Tables and charts present a summarial view of the findings in readily understandable form.

Handbook for Environmental Impact Analysis. Draft for Department of the Army by R. K. Jain, L. V. Urban, G. S. Stacey, Construction Engineering Research Laboratory, Champaign, Illinois, April 1974, 206 pp. 12 figures.

Recommended procedures for use by Army personnel in preparing and processing environmental impact assessments (EIA) and statements (EIS). A method for evaluating environmental impacts is presented that employs an "attribute descriptor package" - an environmental factor index and a matrix analysis with summary comparison of individual attributes (environmental characteristics) by bar charts. The problems of determining relative importance and severity of impacts, and of providing a single number to indicate total environmental impact (thereby masking the distribution of the impact among its attributes) are avoided by assuming that each attribute is of equal importance.

A Manual for Conducting Environmental Impact Studies. W. L. Ellis and J. E. Lewis, Virginia Highway Research Council, January 1971, available through the National Technical Information Service PB-210 222, 39 pp.

This study suggests techniques to be employed in the location of highways. One technique is designed for each stage of the highway development process: conceptual, location, and design. The techniques suggested are primarily guidelines and rely heavily on the input from professional and interested concerns. Weighed values are placed on highway impacts and dollar values imputed for the same. A ratio is then formed which serves to demarcate the least harmful alternative.

Matrix Analysis of Alternatives for Water Resources Development. Draft Technical Paper by Corps of Engineers, Tulsa District, July 31, 1972, 40 pp., 4 tables.

A computerized matrix analysis approach to environmental assessment. The study starts with a summarial State of the Arts review as a touchstone for the presentation of its own methodology. Both "structural" and "nonstructural" alternatives are to be considered. The approach relies on an interdisciplinary team to select a reasonable number of alternatives from those possible, to select a reasonable set of parameters and to determine their weighing and scoring. The parameters are subsumed under three headings: natural, human, and economic. A computer program **is** used to perform a statistical analysis of the matrix data previously determined by the interdisciplinary team.

A Methodology for Assessing Environmental Impact of Water Resources Development. Final Report for Department of the Interior by Environmental Impact Center, Inc., Cambridge, Massachusetts, November 1973, 148 pp., 32 figures, 19 tables.

A new method of analysis is recommended that integrates existing analytic techniques into a single unified methodology. The model structure is modular with each of the six sectors - water, biology, population, industry, land use, and recreation - analyzed separately using various cost/benefit, matrix, and computer modeling sub-systems. Interrelationships between sectors are outlined.

"A Methodology for Interactive Resource Policy Simulation." Kane, et al, Water Resources Research, 9)1), 1973, pp. 65-79, charts, matrix.

A para-mathematical technique of environmental assessment. The authors feel that computerization is a needed facet of assessment yet comprehensiveness should not encompass the whole decision process. The study developes a simulation procedure (KSIM) which describes complex interaction of both "hard" and "soft" variables while not requiring mathematical simulation in its use. Further, KSIM is touted as easily modified and totally flexible. The KSIM approach utilizes geometric concepts and an interaction matrix. The authors have 2 purposes for introduction of the system: (1) to iterate that high order complex systems do not respond continuously to small changes but rather have a critical threshold, and (2) to impart a new pattern of holistic thinking.

Model for Landscape Resource Assessment. Julius G. Tabors, Water Resources Research Center, University of Massachusetts at Amherst, Part 1 of the "Metropolitan Landscape Planning Model," February 1973, 34 tables, 33 illustrations.

The development and application of a landscape resource assessment model designed to estimate landscape change, both positive and negative, caused by urbanization in the Boston metropolitan region since 1945. The model incorporates the quantitative assessment techniques which were designed to estimate water quality, the use of questionnaires, matrices, mapping of value change isopleths, and other sub-models for parameter evaluations. This is only the first step - a second step is planned that will be designed to provide planners with a model for land use allocation and land use activity management.

Optimum Pathway Matrix Analysis Approach to the Environmental Decision Making Process. Odum, Ziemen, et al, Institute of Ecology, University of Georgia, Athens, Georgia - Testcase: Relative Impact of Proposed Highway Alternatives, 1971, unpublished report, 36 pp., 1 map, 13 tables, 1 chart.

This study singled out by objective analysis the best route from 8 proposed alternates for an interstate highway project. Project actions and environmental, human, and economic factors are compared by computer analysis employing scaling factors, weighting factors, and component values. Future impacts were given greater weight than present. The program accounts for imprecision by allowing a random error of 50%. Confidence intervals for the given alternatives are computed and compared.

A Procedure for Evaluating Environmental Impact. Luna B. Leopold, et al. U.S.G.S. Circular 645, 1971 (13), special report, 2 tables.

A proposal for environmental impact assessment. A matrix is employed as a two-dimensional checklist as the first step toward defining cause-effect relationships between components of the project and elements of the environment. A dichotomy of magnitude and importance derived from value judgements is used to rate the impact of each element in the matrix. The study concentrates on first order effects to avoid unnecessary replication. The major advantage of this system is the ordered comprehensive approach to the problem of assessment.

"A Statistical System for Estimating the Deterioration of the Human Environment." R. Hueting, Statistical and Mathematical Aspects of Pollution Problems, J. W. Pratt, ed., pp. 123-132, charts, figures.

An innovative approach to environmental impact. The author measures deterioration in the environment as decreased availability of functions of an environmental component. Such a decrease would be the manifest result of competition of functions: hence in assessment, one should analyze where competition of functions takes place thus tagging a deleterious effect. The author sees this competition taking on quantitative, spatial and qualitative aspects. In schematic representation indicators are used with statistical reflection in the compilation of "cells" which serve as units in planning processes. This paper is concluded with a section on the shadow pricing of environmental functions.

Three Approaches to Environmental Resource Analysis. Prepared by Landscape Architecture Research Service, Harvard University, and The Conservation Foundation, Washington, D.C., November 1967, Research Association - Raymond K. Belknap and John G. Furtado, 23 figures.

An overview of three land use planning analysis methods: G. Angus Hill, Phillip H. Lewis, Jr., and Ian L. McHarg. The three methodologies are compared on: (1) their identification of spatial and environmental patterns beyond single factor analysis and simple spatial location, (2) their identification and evaluation of key elements and forces that affect the quality of the environment, (3) their review of analysis material for incorporation in the planning process, and (4) their treatment of the environment as an entity.

note bibliography for books by each author, also good examples of McHarg's method can be had in: Woodlands New Community Medford, both published by the Center for Ecological Research in Planning and Design, University of Pennsylvania

PART B: RELATED ISSUES AND ARTICLES

Aesthetics in Environmental Planning. Prepared for U.S. Environmental Protection Agency by Washington Environmental Research Center, Washington, D.C., November 1973, 187pp., 6 illustrations, 4 tables.

One finds different levels of comprehensiveness in various agency guidelines and planning procedures. This study not only reviews basic research in but also recommends systematic methods for the inclusion of esthetic considerations in the planning process. A wide range of numerical and non-numerical, visual, and user-analysis methodologies are explored.

An Analysis of Environmental Statements for Corps of Engineers Waste Projects. Ortlano, et al, Report 73-3, distributed by NTIS, Springfield, Virginia, AD-747-374.

A useful touchstone for preparing assessment reports. This study provides a checklist of effects for environmental assessment: projects from levee building, groin and weir construction, to borrow pits are reviewed while possible areas of environmental harm are listed. The substantive comments on secondary, long term, and alternative project impacts as well as value orientation might prove valuable in aligning one's assessment procedure.

"Approaches to Value Choices." Norman Wengert, Regional Planning - Challenge and Prospects. New York: Frederick Praeger, 1969, pp. 98-102.

"This article discusses the problems of values in environmental planning. The author points out that environmental decisions will be affected by the often conflicting goals of different professionals with different objectives. Such differences are based on technological background, authority, and associates of each person involved. To deal with such difficulties, the author suggests three basic needs. The values must be identified, an awareness of mechanisms and processes for making value choices must be developed, and it must be recognized that value decisions often involve hard choices. The author stresses the importance, in decision-making for environmental planning, of a cost benefit analysis of the factors involved."

"Assessing Environmental Impact." Frank L. Cross, Jr., Pollution Engineering, June 1973, Vol. 5, No. 6, p. 34(2), technical feature, 4 tables.

An examination of scientific and matrix analysis. The author compares scientific and subjective impacts and value judgement techniques. He reviews the methodologies of Leopold, Battelle and the Army Corps of Engineers. It is suggested that environmental data should be charted on an Assessment Function Curve, which may well not be linear.

"Broadening the Approach to Evaluation in Resource Management Decision-Making." W.R.D. Sewell, Journal of Environmental Management, Vol. 1, 1973.

This article concerns itself with the presentation of a descriptive model of the policy-making process. Also examined is the extent to which present procedures of evaluation are able to provide the data required by decision makers. The entire identification, evaluation, and selection process is examined. The author states that the opportunity costs of using a resource for one purpose rather than another is too often not considered as a part of the environmental impact. Further he argues that assessment procedures are biased toward development as he points out several other salient shortcomings in the present method of evaluating environmental impacts.

Burrard Inlet Ecological Study for the City of Port Moody. H. H. Lindeman. Vancouver, British Columbia: Eikos Consultants, Ltd., 1972.

"Presents an environmental evaluation methodology measuring how well an area meets an ecological objective or set of objectives for the ecosystem. In the example, a prime objective is to maintain and improve the environmental quality essential to the well-being of the flora and fauna of the diverse habitat."

"The Classification and Evaluation of Land for Multiple Uses." G. A. Hills, Forestry Chronicle, June 1966, pp. 1-25.

"A summary of the principles and methods employed in the development and application of the following research: (1) Classification of the physiographic (soil and climate) features of land and water bodies, and (2) development of methods for rating physiographic classes for various uses within an ecological framework. Such evaluation studies are done for timber production, wildlife production and outdoor land-oriented recreation."

"A Comparison of Public and Resource Administrator Visual Perception of an Outdoor Water-Based Recreation Area." Report by Institute for Research on Land and Water Resources, Penn. State University, University Park, Pennsylvania, 133 pp.

Through sampling of public's and administrators' view on the quality of recreation area environments, problems of weighting of administrative decision-making are revealed. The study concludes that the average citizen does not generally perceive in a different or opposite manner from resource administrators, though each differed consistently in the homogeneity of their responses to the same environmental resource. The authors found agreement in principle but disagreement in application. The important implication of the study is that resource administrators will continue to have difficulty in including the public in the resource planning process.

"Comparison of Techniques for Impact Assessment." Outline of lecture prepared by Richard N. L. Andrews for Environmental Impact Assessment Short Course, sponsored by U.S. Army Corps of Engineers Institute for Water Resources, June 1973.

A review of existing techniques and their ability to perform the tasks of environmental impact assessment. The author sees six principal tasks: (1) the selection of "evaluative factors", (2) identification of the relationships among the evaluative factors, (3) formulation of alternatives, (4) forecasting of effects of each alternative on evaluative factors, (5) display of the difference (or "trade offs") among the alternatives, and (6) evaluation of tradeoffs among alternative courses of action. The various techniques now under development or in use by consultants, such as the matrix procedure developed by Luna Leopold, the Battelle-Columbus Laboratory's "Environmental Evaluation System" and others, are compared in their ability to perform these tasks.

"A Conceptual Framework for Applying Environmental Assessment Matrix Techniques." B. Schlesinger and D. Daetz, Environmental Sciences, XVI, No. 4, July-August 1973, pp. 11-16, 3 tables.

The matrix approach gets a heavy reappraisal and emerges as newly finished yet valuable assessment tool. The authors add to the matrix the concepts of "interrelationship" and "probability of occurrence." A description of parameters as well as several necessary predications for matrix use are included. Concluding the paper is a delineation of the value of matrix analysis in all steps of the planning-decisionmaking process.

Constructing Nonlinear Dynamic Models for Socio-Environmental Decision-Making: A Methodology. California University, Davis Institute of Governmental Affairs.

"A methodology for the development of socioeconomic system submodels which might be integrated into environmental impact studies is presented. The so-called method of 'quasilinearization' is incorporated into the model building procedure in order to obtain values of unknown and important parameters. As an example illustrating application of techniques proposed in the model construction methodology, the socioeconomic system of the Lake Tahoe Basin is modeled and unknown parameters in the model identified. It is concluded that social systems experts with little or no mathematical background can be included in the model building process, parameter identification schemes can be employed to determine selected model parameters, re-evaluation of the model after data collection is critical, and methods used for interpretation of some data is a major weakness in the present version of the model. Some topics (are) suggested for future study...."

"Cost Benefit Methodology for the Selection of a Nuclear Power Plant Cooling System." Dr. Steven Salomon, presented at the Energy Forum, 1974, Spring Meeting of the American Physical Society, Washington, D.C., April 22, 1974.

An approach to environmental assessment with a decided economic slant. The author proposes two matrices--a cost-benefit factor matrix and a decision matrix. Environmental impacts are subsumed under socio-economic impacts. In the decision matrix, weighting factors are assigned according to a logarthmic scale--amenable to the mechanics of sensory perception. These factors are then multiplied by "impact scale factors" to yield an array of numbers. The alternative with the smallest number is selected. Charts, figures, tables.

Ecological-Economic Analysis for Regional Development. Walter Isard. New York: Free Press, 1972.

"This approach begins with the standard economic input-output analytic method, adds ecological sectors to it. Conceptually interesting but goes far beyond available data."

"Ecological Evaluation of Land for Planning Purposes." Biological Conservation, Vol. III, April 1971, pp. 167-172.

An approach to land evaluation and subsequent environmental assessment. "Ecological Zones" are defined in terms of "relative rarity" and "species diversity". Values are imputed ordinally according to specified criteria. The author claims the merit of simplicity in this approach. Having assigned a "scoring" and a "category" to each zone the final product is termed the "Relative Ecological Evaluation Impact". Several applications of this method are reviewed.

Ecological Simulation for Aquatic Environments. Final Report, prepared for Office of Water Resources Research, USDI, December 1972, Chen and Orlob, charts, printouts, diagrams.

A method of modeling ecosystems and predicting environmental impact. This study assesses the impact of water resources development on aquatic ecosystems considering not only environmental but also attendant economic and social gains or losses. An ecological model is developed with a set of balanced equations to be solved over a time space continuum appropriate to the project. As many as 22 parameters and their couplings are considered simultaneously by the model.

"An Ecologically Based Simulation-Optimization approach to Natural Resources Planning." Swartzman and Dyne, Annual Review of Ecology, Vol. 3, 1972, p. 347 (51), printouts, figures, equations.

With the increased implementation of the multiple-use concept and upon consideration of endemic variables and probablistic inputs of such factors as climate, the demand for models and other computer tools is evidenced. These research techniques involve seeking optimal action by systematically analyzing objectives, effectiveness, cost, and risks of alternative management strategies. The novelty of this approach is found in combining both simulation and optimization models. The simulation model is depicted in matrix form, computer produced, utilizing indicators of flow between row and column variables. The simulation model evaluates such components as driving variables, edaphic features, and plant dynamics. The liner programming model is fed with information from the Simulation Model. Objective functions are defined and print out results are subject to various constraint functions. This approach also utilizes feedback from the optimization model to adjust conditions in the simulation model. The authors see lack of data for validation of model outputs as inability to handle "non dollar value criteria", as representitive of problems requiring furthered research.

"Environmental Analyses: A Set of Tools for Land Use Planning." James A. Roberts, paper to be submitted at September 1974 F.I.G./ASCM/API.

A tripartite paper that addresses the inclusion of environmental assessment in the planning process rather than as a post facto exercise. The author discusses--(1) environmental sensitivity analysis, (2) environmental impact analysis, and (3) land use planning and environmental analysis. A methodology for environmental sensitivity analysis is presented which includes the formulation and evaluation of "Environmental Sensitivity Matrix", an "Environmental Weighting Matrix" and an "Environmental Sensitivity Map". Once sensitivity indices have been determined for all environmental parameters, the Environmental Weighting Matrix determines the relative significance/importance of each environmental element in relation to each of the other environmental elements. Sensitivity values are then weighted prior to summation using a Relative Ecological Value (REV). A summarial map depicts sensitivities in the project area. The ideas espoused seem to be a viable middle road between quantification and qualification of environmental assessment.

"Environmental Assessment." Anderson, et al, Environment: A New Focus for Land Use Planning, Donald M. McAllister, ed., RANN Publications, National Science Foundation, Washington, D.C., October 1973, pp. 291-300, 5 tables, 18 figures.

Conclusions drawn by the National Science Foundation's RANN-sponsored workshop on how environmental/land use planning research requirements might be met, and on identifying the areas of new knowledge needed by planners and decision makers.

This article is the result of a committee study on assessment procedure. The planning process is given a taxonomic structure that essential environmental systems might be incorporated. The authors see all techniques of assessment as falling into two categories - those that try to avoid the pitfalls of benefit/cost analysis, and those that try to augment benefit/cost analysis. The problems of assessment and research needs are outlined.

Environmental Assessment Report. Muskegon County Board, Muskegon, Michigan, March 1971, 47 pp., EPA Demonstration Project #11010 GFS, 5 tables, 10 figures.

"The Muskegon County Wastewater Plan entails the collection and treatment of municipal and industrial wastewaters that are generated in the urban areas focusing on the dune impounded Mona, Muskegon, and White Lakes. Wastewater constituents are used as resources to be applied through irrigation to the land where they are used as a soil conditioner or as nutrients. The environmental impacts of the Plan are grouped and discussed under three headings: (1) impacts on the water resource, (2) impacts on the air resource, and (3) impacts on the land resource. In addition to the system currently being implemented, three alternatives were considered."

"Environmental Impact Analysis: Tool for Better Design." Architectural Record, Vol. 155, February 1974, pp. 65-66, charts, sketches.

A perspective on the role of environmental assessment in the planning process. The author sees any plan as a creative response to a set of constraints which in part are determined by environmental impact analysis. He sees the simplist end of the assessment spectrum occuring where environmental analysis reveals a natural ordering system.

Environmental Impact Hearing: Stewart Airport Runway Extension. DMG-DRS J, Vol. 7, No. 5, January-March 1973, p. 65 (6), technical report, diagrams, map, tables.

A methodology used to analyze the information collected at an Environmental Impact Hearing for the Stewart Airport runway extension is provided. The airport extension project, carried out by the Metropolitan Transportation Authority, would provide a fonar jetport for the New York Metropolitan area. However, in order for the project to be approved by FAA a satisfactory environmental impact statement must be completed. Information needed to compile such an impact statement is presented, with natural resources, man-made resources, human resources, economic resources, and aviation program needs organized into matrix tables.

Environmental Impact Matrix Printout. J. Sorensen, contact Mr. B. Hanshaw, USGS, Denver, Colorado.

Serving as a supplement to Sorensen's ongoing studies, this circulation lists impact considerations from a data bank for a series of project activities. The impacts are listed in heirarchical fashion from the more general to the specific. Attention is also given to economic costs and trade-offs. While the printout addresses itself to coastal projects, the technique is of importance for it represents a viable approach to interagency-information-access on environmental assessment.

Environmental Impact. Proceedings of the American Society of Civil Engineers ASCE Urban Transportation Division, Speciality Conference, Chicago, Illinois, May 1973, 393 pp.

A wide range of attitudes and technical processes necessary to the preparation of an environmental impact statement are explored. Papers are presented in four areas: (1) procedures and public participation, (2) air and noise effects, (3) social, ecological, and water quality, and (4) total impact evaluation. Emphasis is placed on the selection of alternative corridors and/or modes for transportation systems.

"Establishing Priorities Among Environmental Stresses." H. Requiam, Indicators of Environmental Quality Proceedings, Symposium, W. A. Thomas, ed., Environmental Science Research Series, Vol. 1, p. 71 (12), tables, figures.

An appraisal of the difficulties of environmental assessment. Author notes there is difficulty in ranking individual environmental problems even among dedicated environmentalists. Apparent effects are often not the most important, and the acute often only shades into the chronic. The author notes that traditional reductionists favor breaking the system down into simple components which lend themselves to a specialized approach. Logistics for handling unquantifiables are presented. One would proceed to make subjective evaluation for each environmental stress using Persistance, Range, and Value indices. The simple product of assessment scales is used to indicate the relative importance of stress with respect to any one of the environmental resources systems.

"Evaluation of Alternatives for Solid Waste Systems." Wenger and Rhyber, Journal of Environmental Systems, Vol. II, No. 2, June 1972.

"A method is presented which incorporates environmental, social and engineering factors into the selection of a solid waste system from among several alternatives. The methodology relies upon the establishment of a data matrix for the criteria and alternatives under consideration and upon the assignment of weights to the various criteria. A stochastic procedure takes account of the inherent uncertainty in the quantitative values assigned to subjective criteria and for the uncertainty in the assigned weightings. An example is included which demonstrates the use of the method."

Evaluation of Environmental Intangibles. N. H. Coomber and A. K. Biswas. New York: Genera Press, 1973, 14 figures.

The available methodologies for evaluation of intangible benefits and costs associated with the use of the environment are reviewed. Various monetary and non-monetary techniques are discussed along with their relative strengths and weaknesses.

"Evaluation of Impacts and Alternatives." Outline of lecture by A. Bruce Bishop for Environmental Impact Assessment Short Course, sponsored by U.S. Army Corps of Engineers Institute for Water Resources, June 1973, 30 pp., 14 figures.

A comprehensive discussion of the principles of evaluation and decision making in impact assessment. Of particular interest is the section entitled "Methods for Multiple Criteria Evaluation" where the author describes and critiques existing methodologies in regard to "(1) how they fit into and work within the evaluation process, (2) their methodological problems, and (3) their value as a mechanism for soliciting public input of values." A matrix is included for summary comparison of the methods.

"Evaluation of Natural Environments." M. Myers, Indicators of Environmental Quality, W. A. Thomas, ed., Environmental Research Series, Vol. 1.

A technique for environmental evaluation and assessment. The author states that the evaluator should be a purveyor of information to a wide circle of interested parties involved in the decision process. He selects two categories of environmental resources for exploration: variability and accessibility. Variability is accounted for by biological mapping and, in proximate areas, is an easily quantifiable index. Author employs Distribution Change Measures (DCM) and Inter-Association Change Measures (IAM) in the assessment of impact.

A Framework for Identification and Control of Resource Degradation and Conflict in the Multiple Use of the Coastal Zone. J. C. Sorensen, Master's thesis published by the Department of Landscape Architecture, College of Environmental Design, University of California, Berkeley, June 1971.

"Included is a methodology of environmental impact assessment as an improvement over U.S. Geological Survey Circular 645. There are four matricos, A (Residential, Commercial, Agricultural), B (Recreational), C (Extractive), and D (Industrial, Transportational). The matrices associate possible adverse impacts, broken down into initial conditions, consequent conditions and effects, with causal factors."

"Getting at the Issues." Willis and Associates, Progressive Architecture, June 1974, p. 82 (5), 1 figure, 5 diagrams, charts.

California is one of four states in the nation to require mandatory Environmental Impact Reports (EIR). The lack of criteria and procedures of standard environmental data, and of methods of evaluation has led to confusion within the building industry. The Building Research Advisor Board (BRAB) has proposed to develop criteria and procedures which would help builders and planners prepare EIRs and help government officials evaluate and process the information.

Honey Hill: A System's Analysis for Planning the Multiple Use of Controlled Areas. Carl Steinitz, et al, U.S. Army Engineer Institute for Water Resources, IWR Report 71-9, 2 Vols., October 1971.

"This is another approach to resource inventory from the perspective of landscape architecture, using computer graded data."

"Impact Analysis Using Differentially Weighted Evaluation Criteria." A. B. Crawford, Multiple Criteria Decision-making, Cochrane and Zeleny, eds., University of South Carolina Press, 1973, tables, equations.

This paper is of two parts: the first deals with a method of analyzing alternative plans using multiple evaluative criteria, and the other discusses its application in an analysis of the value of impacts of several highway corridor alternatives. Delphi techniques are used to generate needed information for the model. After the weights of evaluative criteria are established, a computer-aided analysis procedure yields the impact information. In final, through a computer generated matrix the alternative's value-sensitive consequences can be learned.

Impact of Large Recreational Developments Upon Semiprimitive Environments. An Overview of the MSU-NSF Gallatin Canyon Study, James J. Jezeski, et al. Bozeman, Montana: Montana State University, Center for Interdisciplinary Studies, June 1973.

"One of the best academic studies of environmental impact, heavily funded by the National Science Foundation. Referral summaries of the research appear in Planning Magazine, 16 May 1973, and in the Journal of Soil and Water Conservation for September-October 1973."

"Impact Statements and Impact Assessment." R.N.L. Andrews, keynote address presented to the Engineering Foundation Conference on "Preparation of Environmental Impact Statements," Henniker, New Hampshire, July 29, 1973, 18 pp.

This Paper calls for a reworking of present preparation procedures for environmental impact statements by revamping the earlier stage--the assessment process. The author views the statement as an end-of-the-pipe legal document rather than as a valuable planning tool. Five principles seen as critically important considerations in impact assessment are submitted: that assessment is primarily a predictive process; of interest are impacts on resource functions; actions impact not only on discrete characteristics but on systems; appropriate criteria must be used for selecting the characteristics of alternative actions; functions valued by affected publics and professionals must be identified.

Index of the Composite Environment (ICE): A Basis for Evaluating Environmental Effects of Electric Power Generating Plants in Response to NEPA. M. Bender and S. B. Ahmed of the Oak Ridge National Laboratory, March 1974, 77 pp.

The authors propose "a systematic assessment method that will enable those concerned with fair assessment to see where the the subjective judgements are made, how they affect the environmental balance, and whether they are rational." An index is developed that shows a balance between environmental effects and economics. The Index of the Composite Environment (ICE) for a particular system and site is a function of environmental Damage Characteristics (DC), Controllability Values (CV) and regulatory limits subject to resource and monetary constraints. A monetary cost/benefit analysis is performed in parallel and the resultant values paired with the ICE values to show the monetary change from the use of an alternative.

Institute of Environmental Sciences, 1972, Proceedings. 18th Annual Technical Meeting, pp. 332-382. figures, maps, charts, pic.

This conference included a series of papers in the area of remote sensing. As this mode of environmental impact analysis is ascendant, the articles presented are of value. The authors provide a source of background information on the technical aspects of and an exposition of applications for remote sensing. Articles cover such topics as the depolarization of lazer light from polluted waters, the remote sensing of shore areas, the remote sensing of oil spills, and image analysis.

Interaction Between Resources. USDA National Forest Service, Region 8, Atlanta, Georgia, Environmental Research Group, Georgia State University, December 1973, matrix, maps, tables.

An interesting approach to resource management and the assessment of impact. The study was done in tandem with a socioeconomic analysis of each geographic region. In each region a group of 16 resources was identified as contributing significantly to the economic, social, spiritual wellbeing of the populus. Levels of production on the listed resources are given in a numerical matrix. In a "catalytic process" proposed utilization of one resource to any given degree will yield information via the matrix, of the effects on the other 15 resources.

International Symposium of Modelling Techniques in Water Resources Systems. A. K. Biswas, ed. Ottawa, Canada, Vol. 1, 2, 3, 1972.

An exhaustive compendium of modelling techniques in the field of water resources, specifically in evaluation of pollution levels, discharge/recharge cycles, flood control, economic cost/benefit studies, and general compilation of data. Discussions are presented on the applicability of such modelling processes to environmental management decisions. The editor sees the issue to be very decidely on the side of having a model, no matter how crude, rather than none at all. Papers on the desirable and undesirable qualities of systems methodology are included.

"A Philosophy of Environmental Impact Assessment." R.N.L. Andrews, Journal of Soil and Water Conservation, September /October 1973, Vol. 28, No. 5, p. 197 (7).

A lucid presentation of the underlying reasons for assessment. Three historical rationales are discussed: (1) as a separate process, (2) as a source of information, (3) as a new concept of planning analysis. Six purposes of environmental assessment are envisioned. Assessment problems are laid bare and mitigation measures are discussed.

"Philosophy of Environmental Impact Assessment." B. Flamm, Journal of Soil and Water Conservation, Vol. 28, No. 5, September/October 1973, p. 201 (4).

In this view of the assessment process, preferences are expressed for an operational model dealing with interrelationships. When concern with process and procedures dies down, quality and substantitive aspects can be more attended. He defines adequate statements, explains why a matrix "in suo jure" is not enough. A broad qualitative procedure of environmental assessment concludes the paper.

"A Philosophy of Environmental Impact Assessment." J. Jordan, Journal of Soil Conservation, Vol. 28, No. 5, September/ October 1973, p. 205 (3), figures, maps.

NEPA has resulted in too much attention to its 102 (Z)C and consequently a dimunition of attention to its other parts. The author further states that one cannot discuss a framework for assessment prior to considering assessment in terms of the broader planning process. The methodologies of Johnson, Ortlano, and Andrew are reviewed. A caveat of employing specific methodologies as a singular means of attaining satisfactory environmental assessment concludes the paper.

"Physical Systems Modelling as a Tool in Water Resources Planning." Hill, et al, Engineering Journal, Vol. 56, No. 9, September 19, 1973.

A short critique of past and present Canadian assessment systems. The article notes that only recently have concepts of "environmental quality" and "social wellbeing" been incorporated into these systems. The author presents this interpretation of the assessment-planning process in flow chart format. Attitudes toward economic development that will significantly influence the objectives of environmental quality are noted. In interdisciplinary assessment studies he must define how each specialist views the problem, who will use the model and what is modeled.

A Proposed Methodology for Assessing Alternative Technologies. Philip L. Bereano, et al. Ithaca, New York: Program on Science, Technology and Society, December 1972.

"This approach attempts a tiered categorization of chains of future impacts, somewhat similar to that of Sorensen but not computerized."

"Sociological Considerations in Systems Analysis," "Social Data Requirements," "Assessment as a Predictive Process." Evan Vlachos, papers presented at Short Course Impact Assessment in Water Resources Planning, June 1973.

This paper fits environmental assessment into the overall functions of the human community and social system. "Social Environment" is defined as a tripartite structure of territorial variables, sociological variables, and cultural variables. The author notes in social systems a conflict between short term goals and long range consequences, though the social system can be part of the same methodological considerations which demarcate the interaction of interdependence of all environmental systems and their components. Projects will affect the inputs, throughputs, and outputs of the social system. A "Generalyzed Protocol" (GP) is introduced containing elementary units and basic variables involved in environmental design. The author contends not only should environmental assessment consider alternative and future consequences of a project, it is equally important that assessment be considered as a predictive process, as a way of evaluating uncertainty and as a means of forecasting probable or possible developments. A four dimensional matrix for environmental assessment is articulated.

A Review of Environmental Impact Assessment Methodologies. Prepared for the Office of Research and Development, U.S. Environmental Protection Agency by Maurice L. Warner and Edward H. Preston, April 1974, 27 pp., 1 table.

One author's review of seventeen selected methodologies. Their strengths, weaknesses, and potential range of use are judged in terms of the following criteria: impact identification, measurement, interpretation, and communication, resource requirements, replicability, and flexibility.

"Some Suggestions on the Content and Organization of Environmental Impact Statements." Dickert and Sorensen, Environmental Impact Assessment: Guidelines and Commentary, ed. by Dickert and Comeny, University of California, Berkeley, 1974.

Herein the authors prepare their own outline as a format for handling effectively both content and organization of environmental affectation listings. Several examples are followed demonstrating their variations on a theme. The matrix-checklists can prove of value in analyzing the comprehensibility of one's own assessment process. Indirect, direct, secondary, primary, tertiary, short term, long term, beneficial and adverse impacts are considered.

"Surveying Highway Impact. Sullivan and Montgomery, Environment, Vol. 14, November 1972, p. 12 (18).

A perspective on highway impact assessment. Authors state that the FHWA rightly interprets "environment" in NEPA as inclusive of the human environment. A problem of standardization is seen in the assessment procedure of interstate EISs. The impact of highways, especially through urban areas, is assessed in physical and socioeconomic variables. Present assessment techniques are hardly worthy of the sophistication of our technology, the authors conclude.

Systems Analysis and Simulation Ecology. B. C. Patten, University of Georgia, Athens, Georgia. New York and London: Academic Press, 1971.

a handbook of computer techniques and ecology. Author devotes first part of book to the analytical theory behind computer modelling and to an introduction to the art of computer programming (wherein some knowledge of computer operation would be helpful). The author is of the dynamic model persuasion. He presents both analog and digital methods and introduces a system where both are used in tandem during the evolvement of the ecological model. Author claims some value in his approach both from a descriptive and managerial standpoint. The last part of the book is devoted to case studies to evidence the merit of his system--the structuring of thought during environmental assessment.

A Technique for Environmental Decision Making Using Quantified Social and Aesthetic Values. Developed for Atomic Energy Commission by Battelle, Pacific Northwest Laboratories, February 1974, 242 pp.

Part of a four phase study designed for the evaluation of social, economic and environmental tradeoffs, this project deals with the measurement and quantification of aesthetic and social values pertaining to nuclear plant siting. A method is devised for combining social values with "techno-economic values." Derived social values become weighting factors for the techno-economic values. A survey was drawn up to measure respondents direct weighting of eight criteria in the order of importance. First order and multiple correlation analyses were performed on the data to deduce significance. Also, a method for quantifying aesthetics is developed. Relationships between viewscape quality and its basic components: attractiveness, vividness, and unity were expressed by "fundamental equations." A technique is explained for determining the number of viewpoints to be used in defining a viewscape, determining the structural impact on each viewpoint, and for collating these measurements into an index of aesthetic impact.

"The Treatment of Risk and Uncertainty." Hirshleifer and Shapiro, Public Expenditures and Policy Analysis, Haveman and Margolis, eds. Chicago: Markham Publishing Company, 1970.

A proposal for the handling of uncertainty in decision making. This article is of special interest to those persons who wish to refine their assessment procedure by incorporating future uncertainty and hence resulting in a more accurate product. In keeping with recent theoretical trends, the uncertain future is pictured as a set of hypothetical alternative "states of the world." Claims to present consumption and claims to future consumption would be valid if and only if their respective alternative states of the world exists. A Present Certainty Equivalent Value (PCEV) is developed through a mathematical process as the generalization of the Present Value (PV). While the article addresses itself to issues of primarily economic nature, environmental terms can be readily applied.

Upper Mississippi River Comprehensive Basin Study." "Appendix B--Aesthetic and Cultural Values," Phillip H. Lewis, Jr. and Associates for USDI, National Park Service, Northeast Region, 1969.

An environmental resource inventory and analysis that attempts to locate and to record graphically major scenic, recreational, landscape, and cultural features/parameters, that have previously been considered intangible and unquantifiable. While only a small part of a much larger and comprehensive study, this report is an example of an inventory mapping and overlaying technique for environmental analysis. The author's concept of environmental "corridors" is also presented.

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